6.5 TEST EQUIPMENT FABRICATION REQUIREMENTS

Test equipment intended for use in flight must conform to the requirements described in this section. These requirements are separate from those required by the providing Centers' safety organizations. In the event a conflict occurs, the most stringent requirement will be used. All calculations and certifications required in this section should be included in the test equipment data package.

6.5.1 Structural Requirement

All test equipment provided by the using organization must be constructed to withstand the following flight loads in the takeoff and landing configuration:

1. Forward (eyeballs out) - 9 g's
2. Aft (eyeballs in) - 3 g's
3. Lateral (eyeballs left and right) - 2 g's
4. Up (eyeballs up) - 2 g's
5. Down (eyeballs down) - 6 g's

Structural calculations for the takeoff and landing configuration should be based on the yield strength of the hardware. The in-flight test configuration should be designed for a possible 2.5-g force at maneuver entry and exit. Free-float test articles should be designed for a possible 2.5-g force from any direction due to possible recovery on an end or side after a maneuver.

Each structural analysis must include, as a minimum:

1. Structural drawing or diagram.
2. Stress calculations results (if in table form, at least one sample calculation must be given).
3. Component weights.
4. Material properties.

6.5.2 Pressure Vessel Certification

All pressure vessels and pressurized systems used in the Reduced Gravity Program shall be certified as safe to operate before use and shall be recertified periodically if re-used. This certification verifies that the pressure vessel/system has been inspected by a pressure system engineer, relief valves in the system are at appropriate locations, relief valves are certified, all pressure gauges are calibrated, appropriate proof tests were performed, etc.

Each pressure vessel and pressurized system shall be designed to 4 times the Maximum Allowable Working Pressure (MAWP), fabricated, and certified (to 1.5 MAWP) in accordance with applicable national consensus codes such as the American Society of Mechanical Engineers' (ASME) Boiler and Pressure Vessel Code, or other codes acceptable to the NASA JSC Pressure Systems Manager.

It is the responsibility of the test developer to provide the documentation necessary to prove the certification of the pressure vessels and pressurized systems. This documentation will be reviewed by the Reduced Gravity Office and NASA JSC Pressure Systems Manager.

The following is a recommended outline for pressure vessel certification as required in the test equipment data package.

1. System drawing or sketch dated and initialed by designing engineer.
2. Component identification data:
   a. Relief Devices - Set pressure, manufacturer, model number, and system component number of all relief devices. Each valve should be tagged to indicate its set pressure.
   b. Components (valves, filters, regulators, check valves, etc.) - Manufacturer, model number, pressure rating, and system component number. Regulators should be tagged with a certification verification, and all pressure gauges should be calibrated and labeled as such.
   c. Flex hoses - Pressure rating, size, and system component number.
   d. Pipe and Tubing - Material, size, and schedule or thickness.
   e. Pressure Vessels -
      (1) Drawings or specifications that as a minimum specify MAWP, material thickness, material specification, head and shell geometry, and weld joint geometry.
      (2) Serial number or unique identifying number

Note

If vessel is ASME or Department of Transportation (DOT) certified, nameplate or stamped data will fulfill the requirements of (1) and (2) above.

      (3) Certification Tests
         (a) All pressure vessels require proof-pressure testing. Hydrostatic testing at 1.5 MAWP is the preferred method of accomplishing this test. Pneumostatic testing at 1.25 MAWP may be performed, except on DOT vessels, which must be hydrostatically tested.
         (b) All relief valves require set-pressure testing. The set pressure of the relief valve in no case shall exceed the MAWP of the system.

(c) All flex hoses require proof-pressure testing. The only acceptable method of testing flex hoses is a hydrostatic test at 1.5 MAWP.

(d) All system piping requires proof-pressure testing. Hydrostatic testing at 1.5 MAWP is the preferred method of accomplishing this test. Pneumostatic testing at 1.25 MAWP may be performed.

(e) Following off-site certification tests, a certification inspection by a JSC pressure system engineer of the fully configured system is required.

Note

Certification tests must be witnessed by an independent quality assurance representative and adequate documentation must be provided.

3. Inspection Reports - The most current system and component inspection forms and proof-test documentation will be provided by the JSC pressure system engineer.

6.5.3 Electrical

Electrical wiring and interconnect cabling with the aircraft must be fabricated and installed in accordance with *JSC Safety Manual* (current version) and the National Electrical Code. Each piece of test equipment must be adequately grounded and self-protected with an incorporated circuit breaker or other current-limiting device to protect against electrical shorts. Normal aircraft vibration, high humidity, handling, and higher than one-g loads should be considered in connector and wiring selection.

6.5.4 Aircraft Floor Loading

The maximum floor loading should be considered in the design of test hardware. The maximum load density is 200 pounds per square foot (at one-g). Loads exceeding this criteria must have shoring underneath (i.e., ¾-inch plywood sheets) to spread the load over a sufficient area. Rigid test fixtures must have a flexible joint every 10 feet to avoid interference with the normal flexing of the aircraft.

6.5.5 Equipment Mounting

All test equipment should be mounted on base-plates with 5/8- to 3/4-inch holes drilled to match the 20-inch centered grid pattern of nut-plates in the floor of the airplane (see Figure 1) or provide for the use of cargo straps, supplied by the Reduced Gravity Office. Aircraft type bolts, also supplied by the Reduced Gravity Office, are used to secure the base plates to the floor of the airplane.

Attachment bolts and nylon cargo straps will each provide a restraint capacity of 5,000 pounds. All test equipment must be attached so as to withstand the acceleration forces listed in Section 6.5.1. To facilitate loading large and heavy test articles, suitable handles for lifting and carrying, and possibly slots for forklift arms or J-bars, are necessary.

If ¾-inch plywood is used as a base-plate, no individual test article mounted to the base may weigh more than 25 pounds. All bolts used to mount test articles to the plywood must be backed with large area washers with diameters of at least six times the bolt diameter.

6.5.6 Free-Float Packages

Perturbations of the airplane can cause small "g" forces during a zero-g maneuver. If a precise zero-g is required, the test package can be free floated inside the cabin, preventing contact with the walls, ceiling, or floor of the aircraft. To provide the maximum free-float time, the package to be floated should be as light and compact as possible. If an umbilical is used between the floating package and tied-down support equipment, it should be at least 30 feet long to allow the floating package to freely drift. Handles, the length of the longitudinal axis of the package in its floating configuration, should be mounted using ¾-inch tubing approximately 18 inches above the package floor line.

6.5.7 Hazardous Materials

If possible, avoid hazardous liquids and gases, including high pressure, toxic, corrosive, explosive, and flammable materials. If such materials are required for a test, proper containment must be provided. Early contact with the Reduced Gravity Office and the JSC Safety Office for discussions on proper use and containment of proposed hazardous materials may prevent delays in getting approval for the use of such materials. If such materials are necessary, provisions for dumping and purging in flight may be required. A current MSDS must be supplied for each hazardous material.

For hazard material release calculation, the cabin volume is ≈4346 cubic feet. The cabin air exchange rate is one cabin volume per three minutes.

6.5.8 Laser Applications

All lasers must have written certification from Kelsey-Seybold, Environmental Health, Health Physics.

6.5.9 Miscellaneous Guidelines

1. Avoid sharp edges and corners on all test equipment. All exposed edges and corners, sharp or not, must be padded.

2. DO NOT USE liquid electrolyte batteries of any type (battery circuits may require analysis by battery experts to avoid shock, shorts, or overheating). Use of lithium batteries will be reviewed on a case-by-case basis by the test directors and JSC Safety.
3. Avoid flammable materials in test article construction. Any test article with electrical, or heat, or spark-producing equipment cannot use flammable materials, such as plywood, in its construction. (Exception: Use of plywood for weight distribution or as a base-plate for a laptop computer or similar device is acceptable. Any other arrangement must be coordinated with the Reduced Gravity Office.)
4. Consider equipment or procedural failures. Provide backups or work-arounds to prevent such failures from causing hazards to personnel or aircraft.
5. Consider the activities to be performed during the two-g and zero-g portions of the parabolic maneuvers. Structure activities so as to minimize movement during the high-g portions. Consider the need for handholds and/or footholds during the zero-g portions.
6. Experiments involving radioactive materials will be handled on an individual basis with the JSC Radiation Safety Officer concurring on the safety analysis.
7. Cover any glass monitor screens with Lexan or Plexiglas.

Note

An equipment readiness checklist prepared by seasoned flyers is provided in Appendix I as an aid to performing a final check before shipping test equipment to Ellington. However, this checklist does NOT replace the safety requirements of this user's guide.